A Housing Energy Management Program Report

Energy
Ontario

A RESIDENTIAL CONDENSING GAS FURNACE FIELD STUDY

-INSTALLATION REPORT-

REPORT No. 12A

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by

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SUMMARY

With a mutual interest in the energy savings potential of condensing gas furnaces, Union Gas Limited and the Ministry of Municipal Affairs and Housing, through funds provided by the Ministry of Energy, have entered into an agreement to field test such a furnace. Under investigation is the relative performance, both in terms of reliability and energy use, of a commercially available condensing unit with respect to conventional gas and electric heating.

In conducting this field study, a test home was selected and the required equipment installed. Connected in parallel, with appropriate submetering, these three systems (Condensing, Conventional gas and Electric) are able to operate independently. With ambient temperature records and scheduled flip/flopping of the units, one may establish relative energy consumptions as a function of the load demand.

Having completed the installation and commissioning of the study location; this report addresses those difficulties and additional considerations as experienced during installation.

The site itself was scheduled to begin operation and monitoring in September 1983; with test results expected upon completion of the '83/'84 heating season.

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1.0 INTRODUCTION

1.1 STUDY AGREEMENT

Having expressed interest in present high efficiency residential heating technologies, Union Gas Limited and the Ministry of Municipal Affairs and Housing have undertaken to field test a high efficiency condensing gas furnace. With funds provided by the Ministry of Energy, this study is to firstly try and determine seasonal energy figures for both a conventional and condensing gas furnace. With such information, one may begin to establish actual seasonal efficiences and cost avoidances using such equipment. In addition to this, such an installation provides an excellent opportunity to investigate installation procedures and requirements as may typically be found with similar condensing furnaces at other sites.

1.2 SYSTEM SELECTION

In establishing comparitive seasonal efficiences, a decision was reached to operate three separate heating systems in parallel. Aside from the condensing gas unit, a conventional gas furnace and electric plenum heater were to be included. With an assumed on site efficiency of 100 percent, the electric plenum heater would provide a basis from which to establish the heating load characteristics of the house as a function of the ambient temperatures. From this, one could then use the actual energy consumptions and weather information to determine the annual gas heating efficiencies.

In considering the house dependency of seasonal furnace efficiences, particular attention had to be given to selecting a test location which would be as representative of a 'typical' installation as possible. Appendix D outlines those factors as seen necessary to assure a relatively typical installation and one which would generate meaningful information.

In reviewing possible study locations, a site in Wallaceburg, Ontario was finally selected. Built in 1977, this split-level home is of a conventional frame construction with a calculated heat loss of 12.07 Kw. For all practical purposes, this home may be considered typical of many of the newer homes built in southwestern Ontario.

2.0 FURNACE OPERATION

2.1 CONVENTIONAL EQUIPMENT

At the time this site was selected the existing equipment consisted of a conventional gas fired furnace complete with a venturi type inshot burner. The steady state efficiency (from flue gas analysis) and firing rate of the furnace were measured as 75.7% and 29.7 Kw respectively. This equipment may be considered typical of other conventional gas furnaces, in terms of both operation and installation requirements.

2.2 HIGH EFFICIENCY FURNACE

Typically, present day condensing gas furnace technologies address four specific areas in increasing their efficiences relative to conventional equipment. These areas may briefly be described as follows:

1. the removal of sensible heat from exhaust
2. spark ignition versus standing pilot
3. latent heat recovery from combustion products
4. a perceived reduction in infiltration and/or exfiltration from reduced standby flue losses.

The test furnace selected, was in many respects similar to the previously installed conventional unit. Designed and constructed by the same manufacturer, the high efficiency furnace has essentially the same high-boy cabinet and casing design as the other furnace. In pursuing higher efficiencies, the manufacturer has incorporated several additional features. Briefly, these are as follows:

1. stainless steel construction of second and third heat exchangers, the third being fitted with aluminum fins to assist in further condensing the flue gases
2. condensate collection and disposal (with optional condensate neutralizer - not in use here)
3. a power venting blower to draw combustion air through the system and to discharge combustion products
4. appropriate venting switches and equipment (ie. pressure differential switches, pre and post purge cycles, etc.)

5. ABS plastic venting and appropriate termination to remove flue gases (a simple Tee-Y fitting termination)

6. a two speed circulation blower

7. intermittent electronic spark ignition

With these features one hopes to achieve significant gains both in terms of steady state and seasonal efficiencies. The manufacturers claim is of a nominal 95% steady state efficiency.

2.3 ELECTRIC HEATING

To provide electric heat capabilites, a 15 Kw/240V plenum heater was installed downstream of the test furnace. With its load monitoring and current shedding capabilities, this unit should provide sufficient protection to the home electrical system while maintaining set-point conditions.

3.0 FIELD TEST PROCEDURES

3.1 OPERATIONS

Essentially, this test is comprised of operating three seperate parallel systems (conventional gas, high efficiency gas, and electric). In operating these systems on an alternating basis, and with appropriate submetering, one should be able to establish relative energy consumptions (with respect to ambient temperatures) and determine approximate seasonal efficiency figures. Currently it is believed that this flip/flop of systems is the best means by which to conduct such comparative studies. As previously mentioned, the electric heat will serve to establish the heating load curve of the residence from which efficiency comparisons may be made.

Ambient temperature data will be available from two sources. Both on site temperatures and local Atmospheric Environment Services records will be monitored.

3.2 METERING

As implied previously, appropriate submetering will be used to determine the total energy inputs to the respective heating equipment. Such metering has included:

1. gas submetering ,to 0.1 cu.ft. accuracy, to establish relative gas consumptions
2. a 115V electrical meter to record blower and 24V electrical requirements
3. a 240V meter to record plenum heater demand
4. an indoor temperature recorder to monitor the performance of the heating equipment
5. an outdoor temperature recorder to chart local site temperatures

No condensate collection or PH analysis was to be provided. The limited value of such information did not appear to warrant the additional expense.

4.0 INSTALLATION REQUIREMENTS

4.1 GENERAL CONSIDERATIONS

Aside from the additional interconnecting duct work to allow parallel operation of the units, the installation of the equipment was straight- forward. A deliberate lack of supervision was given during the installation of the equipment in order to gain knowledge of potential contractor difficulties. Limited instruction however was provided (over and above that supplied by the manufacturer) covering the additional metering and other test related features. Appendix E outlines those instructions as given to the contractor.

4.2 MATCHING/BALANCING

As in any comparitive study, it is essential that the systems in question operate under as similar conditions as possible. In this study several parameters must be considered.

In matching the equipment, one must obviously address the rated capacitites of the units themselves. To avoid any savings which may be realized by proper sizing, the test furnace was simply matched in size to the existing unit (30.8 Kw) and not to the calculated heat loss of the house. Similarily, the temperature rises and distribution air volumes were matched between the furnaces thus minimizing discrepancies in comfort levels or cycling rates.

Thermostat control, or more specifically anticipator load, was also seen as an area for possible cycling error. Past experience has indicated that an isolating circuit in the thermostat wiring is effective in avoiding such potential problems. Further thermostat difficulties were expressed over the issue of night setback. Although practised quite heavily by this particular homeowner, and becoming generally more common place, a decision was reached to forego night setback for the purposes of this test. In excluding night setback one has eliminated a strongly house dependent load variable which could not otherwise be easily generalized to cover other situations and conditions.

Finally, consideration was also given to matching as closely as possible the external static pressures (E.S.P.) of both furnaces. This condition was required to assure, as reasonably as possible, that both furnace blowers see the same loads and thus draw comparible power.

All final settings and conditions have been included in Appendix A for reference.

4.3 METERING ACCURACY

With conventional gas metering and anticipated low weekly demands (10 cu.m /day), accuracy problems could exist if the standard 1.0 cu.m index was used. To avoid this problem, 0.1 cu. ft. indexes were installed; thus nominally increasing the gas consumption accuracies from 10% to 0.03%. The electric 110 V metering readability has been established as approximately 0.5 Kwh per reading or typically 10%/day (1.5% for the week). This is not of extreme concern as this auxiliary electric consumption is on average only 6 to 8% of the total furnace energy consumption. On 240 V metering, the readability remains approximately 0.5 KWH per reading; for a potential reading error of some 1.0%/day or 0.1% for the week.

5.0 PROCEDURES AND REMARKS

5.1 MONITORING

In recording the required information and switching of the equipment, a decision was reached to have the homeowner carry out these operations according to a pre-arrranged schedule. This it was felt would provide a convenient yet reliable means by which to collect the data. Appendix F is an example of the package as presented to the homeowner, including both operating instructions and a data sheet. Under the agreement, Union Gas Ltd. staff are to closely monitor the results and operation of the equipment in addition to providing the necessary data analysis.

5.2 INSTALLATION REMARKS

In every respect, the work by the contractor was done quite well, in a neat and professional manner. During the installation of the equipment, no real difficulties were experienced by the contractor as a result of the condensing nature of the test furnace. Generally, the contractor was pleased with the equipment both in terms of ease of installation and quality of product.

6.0 COMMISSIONING

6.1 RESULTS

Aside from the general concerns for the operation of the various systems, particular attention was given to two specific areas. The first of these was in the operation of the electric plenum heater. As experience with this equipment was quite limited, additional time was spent assuring that the unit functioned correctly and that all control and safety features operated satisfactorily. The second area of interest was, as previously mentioned, in the matching and setting up of the gas equipment with respect to air volumes, temperature rises, and external static pressures. In commissioning the equipment, no actual equipment or installation difficulties were encountered.

Problems did eventually develop however with respect to the plenum heater. The difficulty was later found to be with a scrap piece of sheet metal which had fallen on to the heating elements, shorting them across and burning out two stages of the heater. This, and the fact that only one side of the 240V appears to be switched at the heater (leaving one leg live to ground), suggests that the enclosed element design as is available with some heaters may be preferred. This however is only an aside to the principal objective of this study and is mentioned only to report our experience.

6.2 INTERIM COMMENTS

Listed below is a brief summary of the conclusions reached to date with respect to preliminary performance results, and installation features of the equipment:

1. The condensing test furnace may be considered 'typical' both in terms of design and construction quality as compared with other condensing units.

2. No difficulty was experienced with the physical size of the unit. To its credit, this condensing unit may be considered relatively compact in comparison to other high efficiency units.

3. Similarily, no difficulty was encountered with input burner sizes (17.6-26.4 Kw). Some problems may exist however at the higher inputs as this model is rated for a maximum of 26.4 Kw. Realistically this should not be of any great concern.

4. The installation of this unit cannot be considered difficult with respect to other high efficiency units, and only marginally so in comparison to conventional furnaces.

5. As with other condensing furnaces, special attention and consideration must be given to the venting and termination of the exhaust.

6. To minimize possible supply difficulties, the manufacturer has selected a ABS venting material as opposed to the norm of PVC Schedule 40. ABS piping and the assorted fittings have generally been found to be more readily available and somewhat less expensive.

7. The standard two speed fan included with this model is again not necessarily the norm. It is however advantageous in many instances (as here) where the application of a continuous blower is preferred.

8. To minimize potential off operation flue losses through the conventional draft hood and vent (ie. as may influence the heating load for the electric and condensing gas furnace) a vent damper was installed in the conventional venting. This was done under close professional supervision and is of course not generally permitted as it may incure a code violation.

9. Because of a lengthy manufacturer delay in supplying the necessary replacement elements, it is unlikely that much electrical heating information can be gained this season.

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APPROVED BY: P. E. DUMOUCHEL, P. ENG.

APPENDIX A

TEST LOCATION

Site -Wallaceburg, Ontario

House Construction -detached single family side split
-1977 frame construction with brick and siding veneer
-3.35 RSI ceiling
-1.94 RSI walls
-1 RSI partially insulated basement
-180.7 sq. m. living area
-12.07 Kw calculated heat loss
-21 degrees C. house operating temperature

Conventional Furnace -Gas fired
-Olsen model HAS-105A

Rated
Input = 30.8 Kw
Bonnet = 24.6 Kw
*Suggested anticipator setting = 0.2A

Measured
Input = 29.7 Kw
Δ T = 47.2 Deg. C.
E.S.P. (Pa) = 32.4 low/74.7 high
Steady State Efficiency = 75.7%

Condensing Furnace -Gas fired
-Olsen model HCS 90/80

Rated
Input = 26.4 Kw
Bonnet = 25.2 Kw
*Suggested anticipator setting = 0.8A

Measured
Input = 26.1 Kw
Δ T = 46.7 Deg. C.
E.S.P. (Pa) = 49.8 low/117.1 high

Electric Plenum	-Federal Pioneer Model CSW15B	
	Rated	
	15 Kw / 3 stage	
	240 Volt single phase	
	Measured	
	Amps. =	62 (approx.)
	Input =	14.8 Kw
	Δ T =	13.3 Deg. C.

* An isolating circuit has been installed to provide a constant 0.41 Amps. to the thermostat.

NOTE:

"Rated"	refers to figures quoted by the manufacturer in sales literature and/or on rating plates with the equipment.
"Measured"	values are as found on site after equipment has been installed and adjusted to operate as required.

Fig.1 TEST SITE

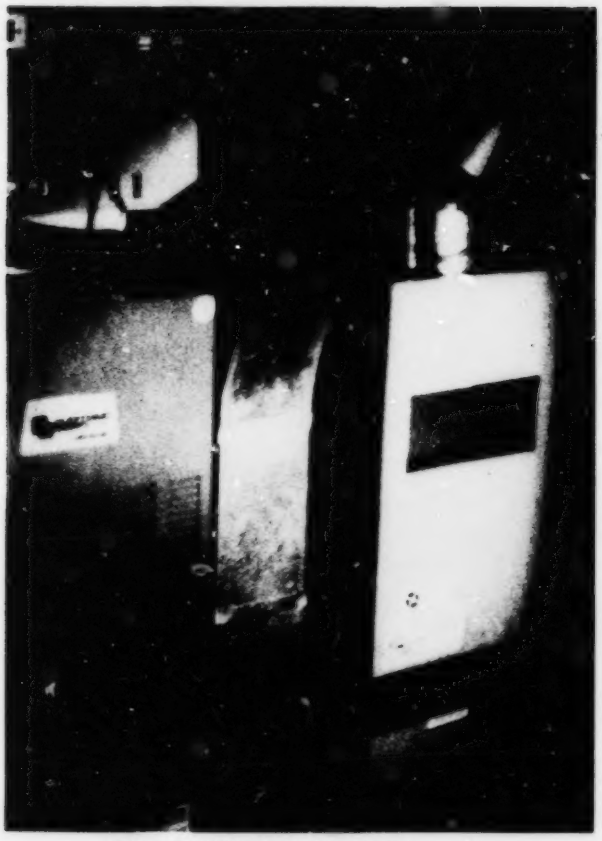
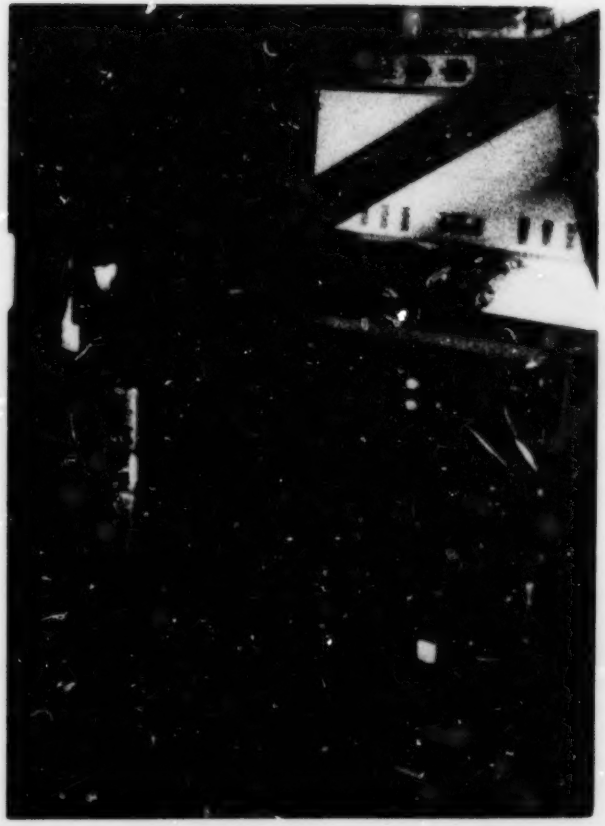


Fig.2 HEATING SYSTEMS

CONDENSING AND CONVENTIONAL FURNACES

Fig. 3



CONDENSING FURNACE AND PLENUM HEATER

Fig. 4

APPENDIX B

INSTALLATION COSTS (1)*

Gas Piping, venting, electrical	$763.00	
Duct work	$400.00	
Total for Installation		$1,163.00
Purchase of Furnace (2)*		$1,650.00
Total (3)*		$2,813.00

NOTES

(1)* - Costs, as quoted by the contractor, include all labour, materials and taxes.

(2)* - The purchase price of the furnace is approximate in that it represents a typical retail price; actual prices may vary. These prices do however include freight and taxes.

(3)* - This total is representative of an actual installation. Study related costs are summarized in Appendix D.

APPENDIX C

MONITORING COSTS

Costs (1)*

Purchase of Electric Plenum Heater	$790.73
Installation of Heater	$557.86
Miscellaneous	$ 40.00
Total	$1,388.59

NOTES

(1)* - Costs are as of this writing and subject to change upon receipt of all invoices.

APPENDIX D

SITE CRITERIA

The following is a list of criteria required of each test site:

1. Natural gas service must be available.
2. The home must be kept at a constant temperature during the heating season. No night setback is allowed.
3. Access to the home must be made available given reasonable notice.
4. The use of any other heating source, such as an electric heater or fireplace, will not be allowed.
5. The existing furnace must have an input between 15 and 25.2 KW.
6. No energy savings alterations are to be done during the test (ie. caulking, weather stripping, insulating).
7. The space requirements of the new furnace is approximately 1.52 m x 2.13 m x 2.13 m (5' x 7' x 7') high. This space is to be adjacent to the existing furnace, as both furnaces will be used in the study.
8. There must be an existing floor drain within 1.83 metres (6 ft.) of the furnace area.
9. The furnace area must be within 4.57 metres (15 ft.) of an outside wall.
10. The homeowner must be available to switch furnaces and record the required data, at or about, the same time each day.
11. A fuel consumption history (ie. 5 yrs.) would be beneficial.
12. A southern location within the company franchise would serve to provide a low degree day installation.

APPENDIX E

INSTALLATION INSTRUCTIONS*

1. Follow the installation instructions as supplied by the appropriate manufacturers.

2. The total equivalent length of 2" ABS venting is to be kept to a minimum.

3. The external filter racks are to be used to hold the new R/A dampers provided this is feasible.

4. The S/A duct elbows are to be rounded as illustrated in the drawings.

5. Install all gas and electrics according to the approved codes.

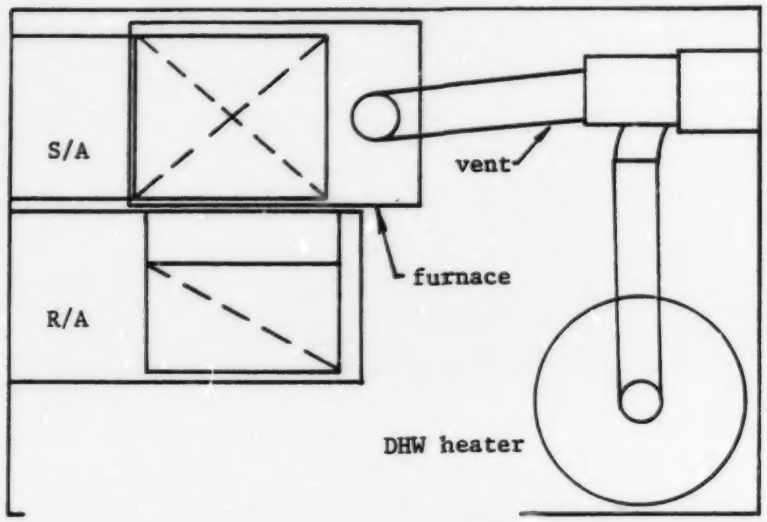
6. Remove 5" take off on top of existing supply plenum.

The new (test) furnace c/w plenum heater will be installed so that each appliance can be operated on a filp/flop basis. At no time will more than one appliance operate.

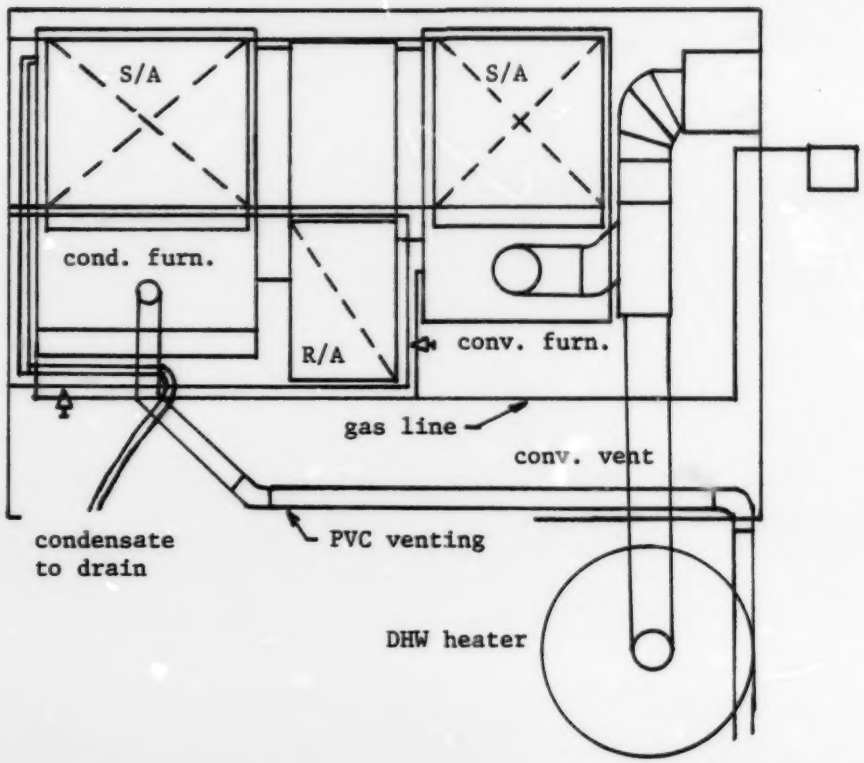
The furnace and plenum heater will be supplied by Union Gas.

* See additional instructions as supplied by the manufacturer.

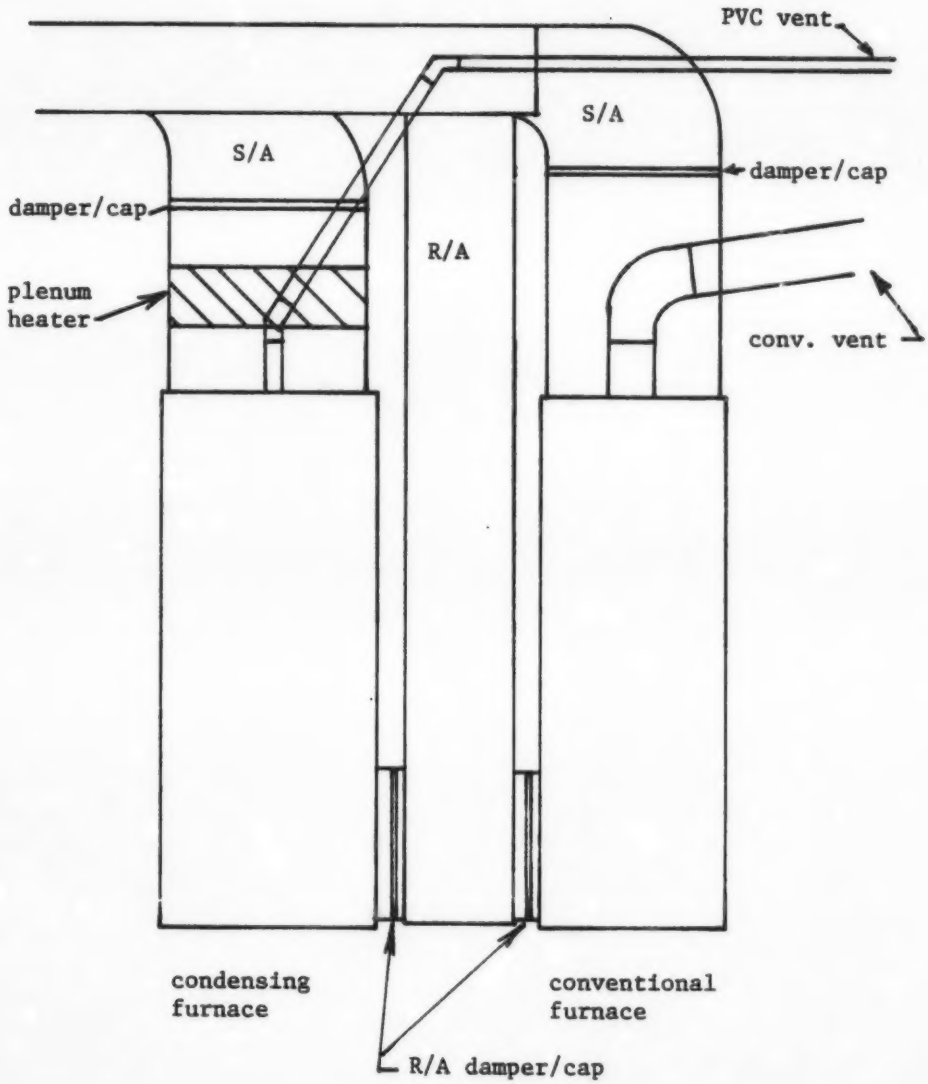
EXISTING DESIGN



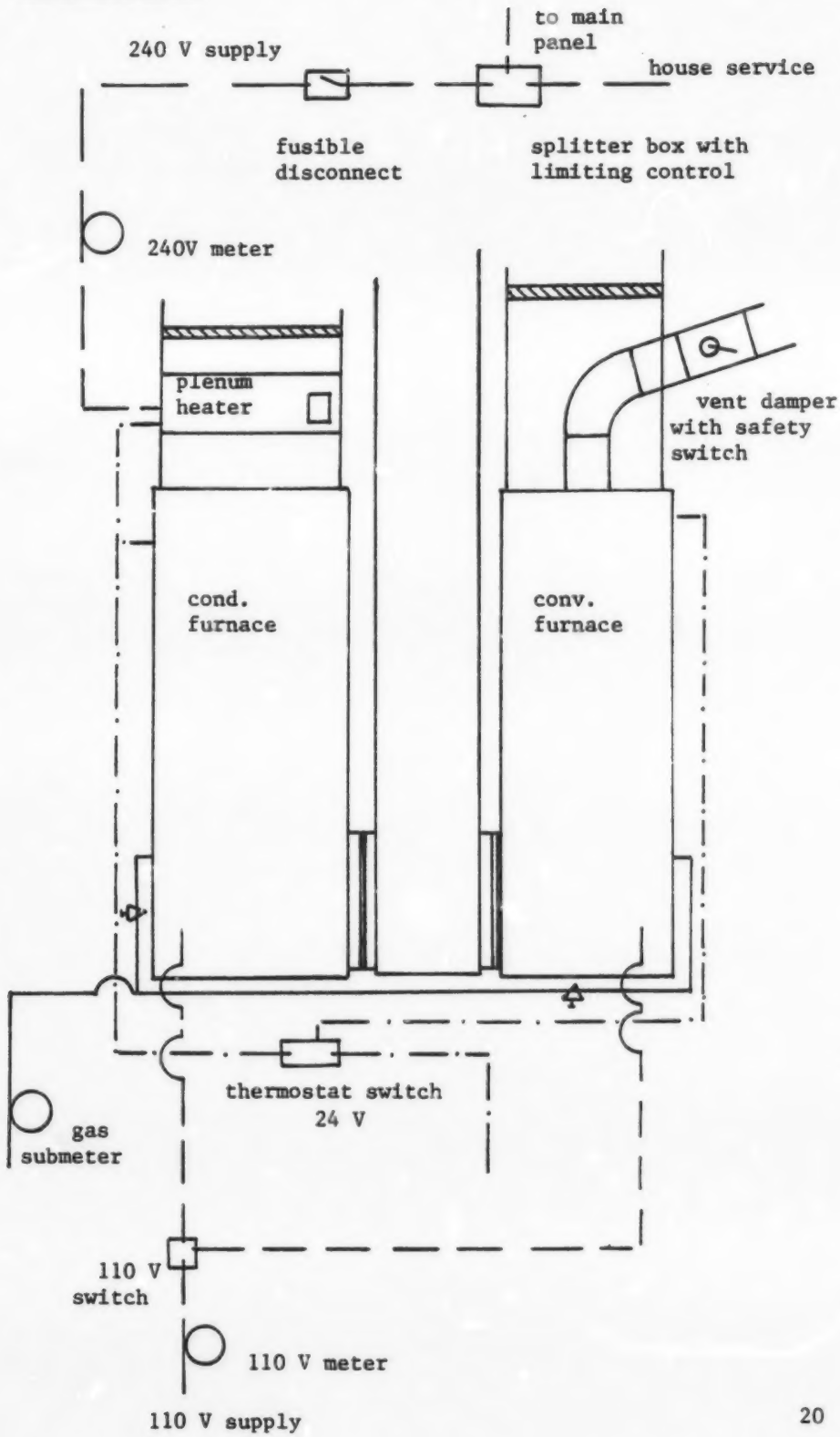
TEST DESIGN



TEST ARRANGEMENT



SITE SCHEMATIC



APPENDIX F

HOMEOWNER'S PACKAGE

- Conventional Furnace Operation -

- Switch thermostat (1) to conventional furnace.
- Remove damper blade (9) and cap opening.
- Remove damper (7), insert filter and cap.
- Insert damper (6) and cap.
- Insert damper (8) and cap.
- Open vent damper (10).
- Turn off gas to test furnace (4) and turn gas on to conventional unit (5) (light pilot)
- Record data (see below) and replace temperature recorder chart.
- Turn main 115V power on to conventional unit (2).

- Test Furnace Operation -

- Switch thermostat (1) to test furnace.
- Insert damper blades (7 & 9) and cap openings.
- Remove damper blade (6), insert filter and cap.
- Remove damper (8) and cap.
- Turn off gas (5) to conventional furnace and on to test unit (4).
- Close vent damper (10) and secure.
- Switch (3) operation to gas heating.
- Record data (see below) and replace temperature recorder chart.
- Turn main 115V power on to condensing furnace (2).

- Electric Heat Operation -

- Switch thermostat (1) to test furnace.
- Switch main 115V power (2) to conventional furnace.
- Insert damper blades (7 & 9) and cap openings.
- Remove damper blade (6), insert filter and cap.
- Remove damper (8) and cap.
- Turn gas off (4 & 5) to both furnaces.
- Ensure vent damper (10) is closed and secure.
- Record data (see below) and replace temperature recorder chart.
- Switch (3) operation to electric heating.
- Turn main 115V power on to condensing furnace (2).

DATA REQUIREMENTS

Upon switching furnace operation, the following data should be recorded:

Data	Meter
Date (day/month)	
Time	
All Electrical Inputs	B (& A where applicable)
Operation	
Gas Consumption	C (where applicable)

GENERAL INSTRUCTIONS

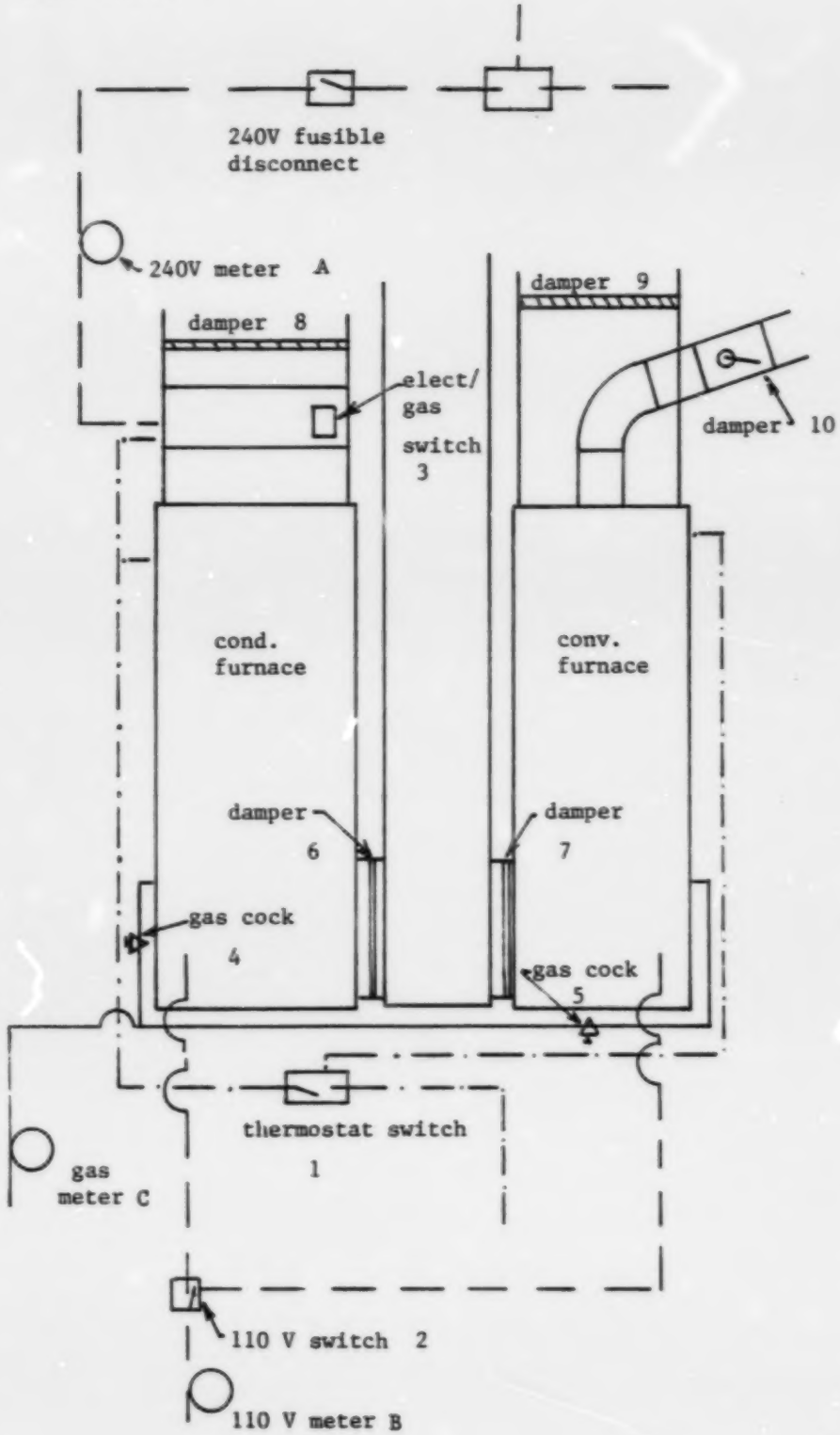
1. The flip/flop changes are to be made on a daily basis, at or near the same time each day.
2. During operation of the electric plenum heater, daily meter readings should be taken as well.
3. In alternating between the various systems, the information as outlined above must be recorded accurately.

4. In recording the kilowatt hours (KWH) care must be taken in correctly reading the meters. These meters should be read to the nearest KWH, with the remainder estimated to the nearest 0.5 KWH.

5. The hundred hour clock should be used in recording time.

   ie. 10:10 PM = 10:10 hours
   11:00 PM = 23:00 hours
   Midnight = 24:00 hours

SITE SCHEMATIC
(Home Owner)



[redacted]ITI[redacted]HIG[redacted]FFIC[redacted]CY D[redacted]ACE [redacted]DY [redacted]

LOCATION: WALLACEBURG

INDOOR TEMP. SETTING: _____

DATE DAY/MO.	TIME (24:00 hrs)	UNIT ON ELEC.	UNIT ON COND. GAS	UNIT ON CONV. GAS			CONSUMPTION METER READINGS ELEC. 110 V (kw hr)	ELEC. 240 V (kw hr)	COND. GAS (cu ft)	CONV. GAS (cu ft)